PANDA: Portable and Adaptable Neutron Diagnostics for ARPA-E

FUSION Program Review (Virtual)
March 5, 2021

Drew P. Higginson, LLNL

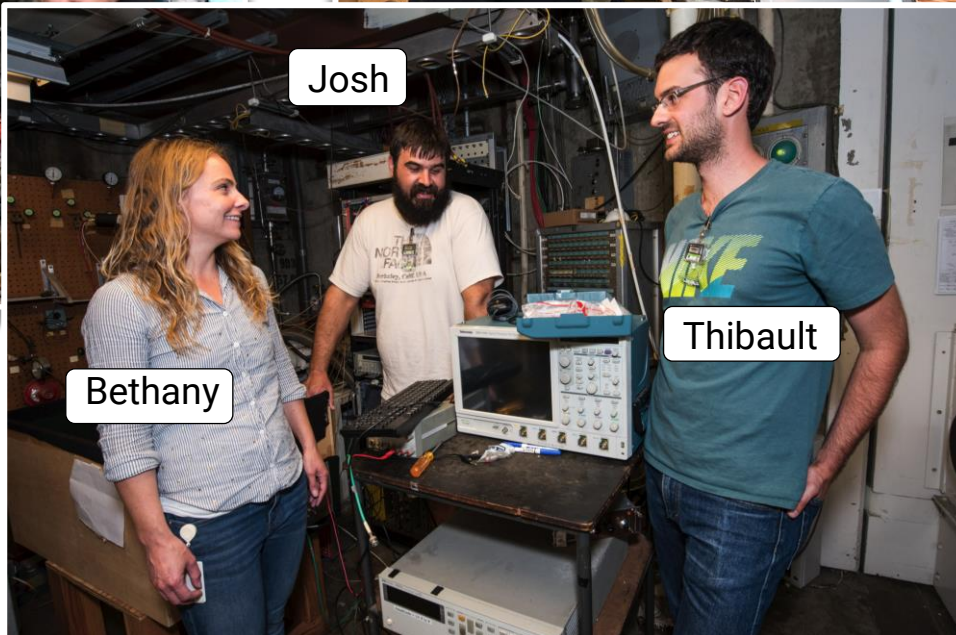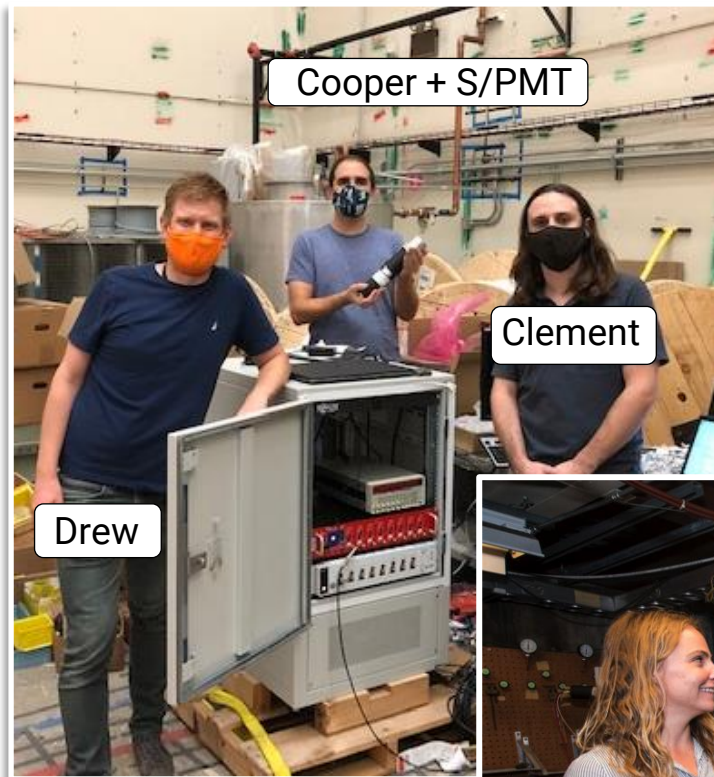**LLNL:** Chris Cooper, Clement Goyon, Matt McMahon, James Mitrani, Amanda Youmans

UCB/LBNL: Bethany Goldblum (PI), Josh Brown, Thibault Laplace

# Team members and roles

LLNL

UCB/LBNL

LLNL Team

- **Drew Higginson** – *PI*

- **James Mitrani** – *Detector design, assembly and calibration*

- **Amanda Youmans** – *Detector assembly, calibration and fielding, data analysis*

- **Clement Goyon** – *LaBr analysis*

- **Chris Cooper** – *LaBr design and assembly*

- **Matt McMahon** – *MCNP analysis of neutron scattering*

UCB/LBNL Team

- **Bethany Goldblum** – *PI*

- **Josh Brown** – *Geant4 simulations and data analysis*

- **Thibault Laplace** – *Pulse metrology and data analysis*

Our diagnostics measure neutron yield and infer neutron energy for neutron emission as small as a few ns to multi-millisecond.
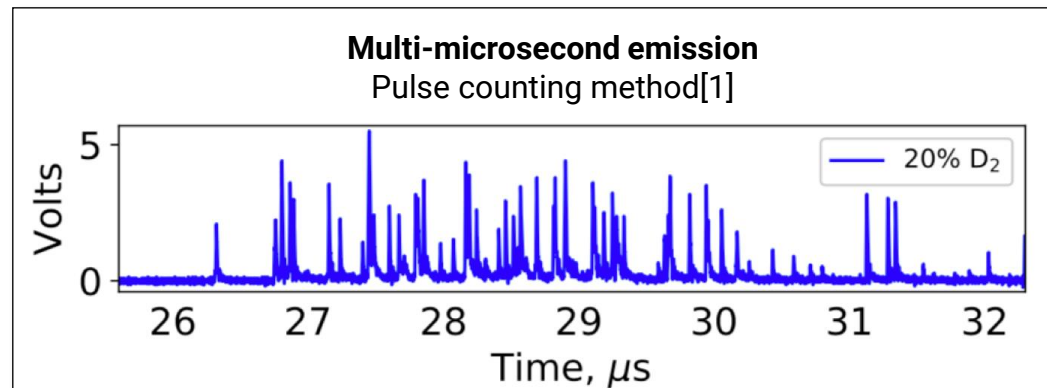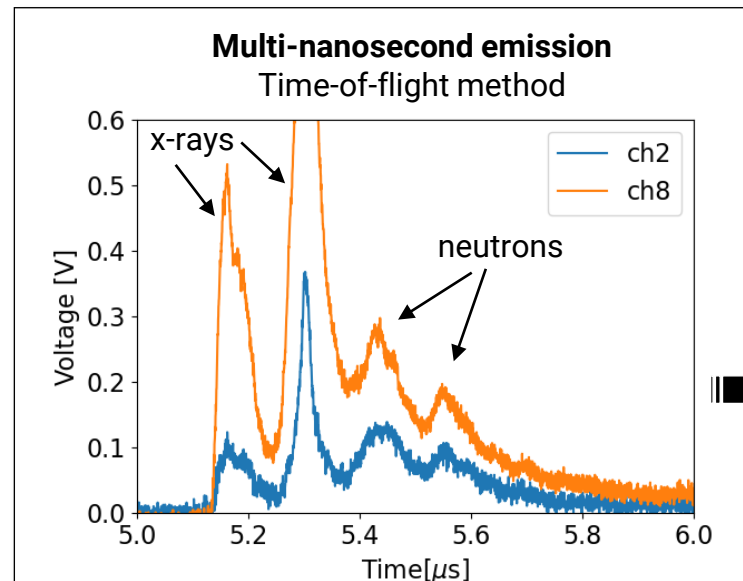

Neutron Yield [into 4π]
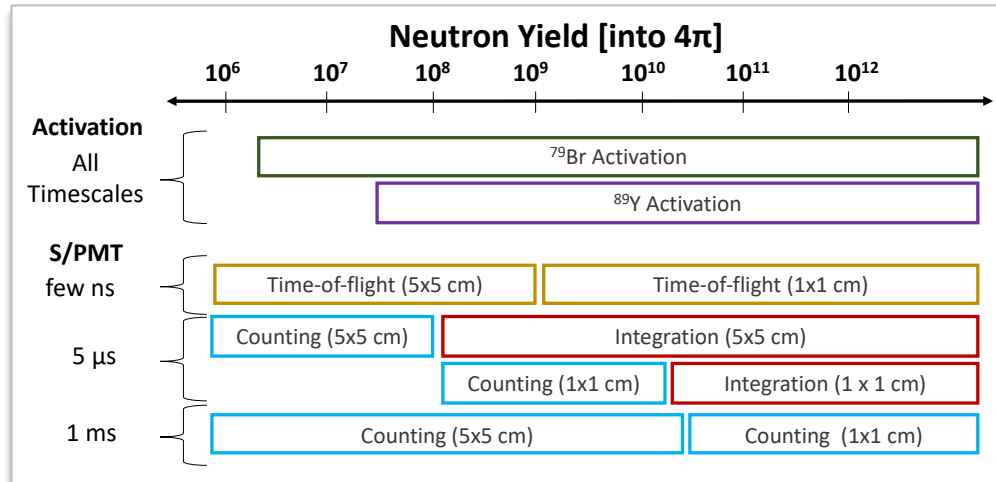
Total neutron yield via activation:
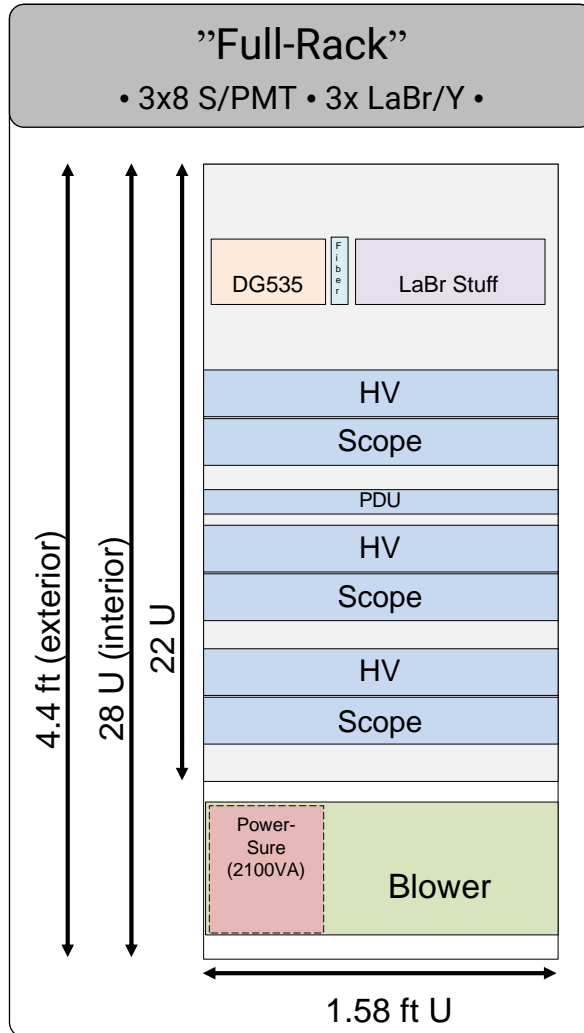
- Viable at yields >5e6 neutrons.

- Yield calculated to better than 20%.

Thermonuclear & beam-target fusion discrimination via Scintillator/PMTs:

- Viable at yields >1e5.

- Few ns emission: time-of-flight method.

- Multi-μs emission: pulse counting method

- Ion beams > 100 keV can be detected.

Multi-nanosecond emission
Time-of-flight method

Multi-microsecond emission
Pulse counting method[1]

Diagnostics ship in single EMI racks that are easy to transport.

"Full-Rack"
• 3x8 S/PMT • 3x LaBr/Y •

- 4.4 ft (exterior)
- 28 U (interior)
- 22 U
- DG535
- Fiber
- LaBr Stuff
- HV
- Scope
- PDU
- HV
- Scope
- HV
- Scope
- Power-Sure (2100VA)
- Blower
- 1.58 ft U

"Half-Rack"
• 2x8 S/PMT • 3x LaBr/Y •

- Simple, compact, easy to transport & non-invasive.

- Detectors: **3x** LaBr activation & **24x** S/PMTs.

- Easy to use scripts; provide raw and analyzed data for the user. Data delivered <3 minutes from a shot.

- We can field and analyze data. We will also teach the teams to run themselves.
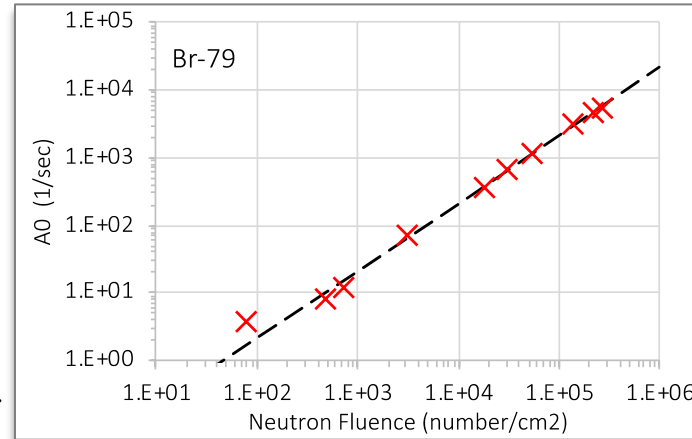
LaBr Analysis Script Outputs
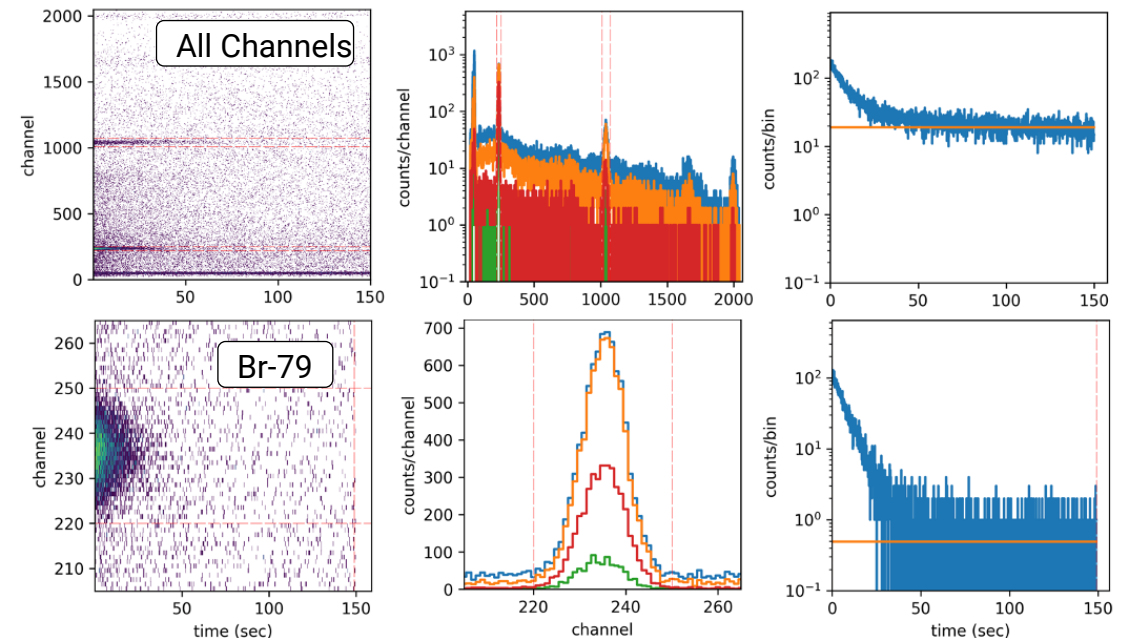
Activation & S/PMTs calibrated & tested on the LLNL Mjolnir DPF
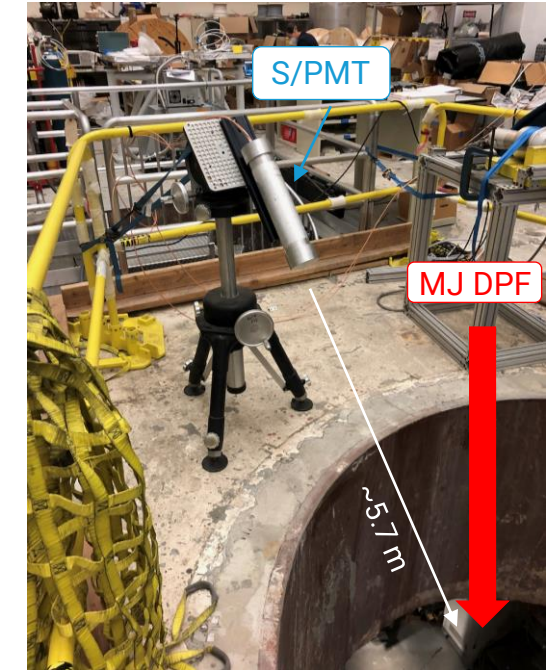
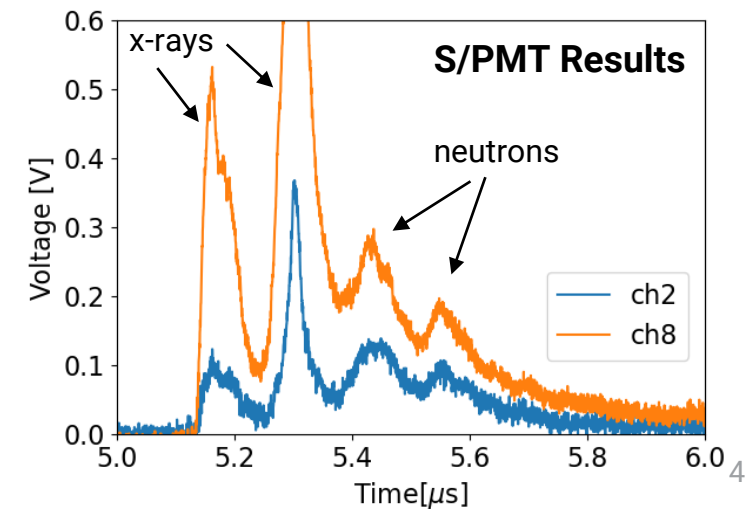**Activation Detector Calibration Setup**
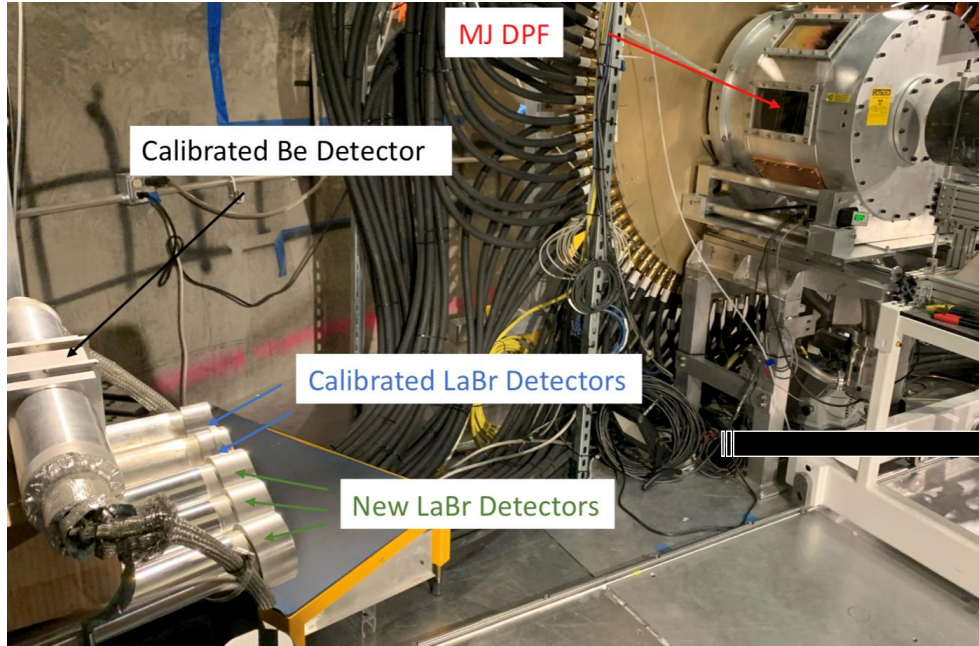
Activation Calibration Results

Distance	Min Yield
20 cm	5.0e+06
50 cm	3.1e+07
100 cm	1.2e+08

S/PMT Test Setup

S/PMT Results

- Calibration and test shots taken on the Mjolnir DPF at LLNL

- Diagnostics performed very well in this harsh environment.
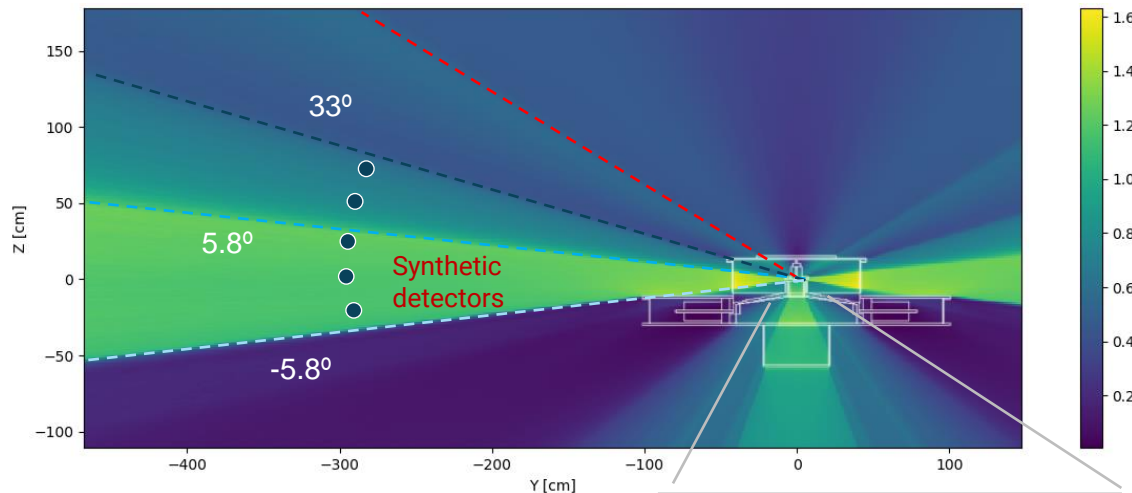
- All systems ready for deployment.

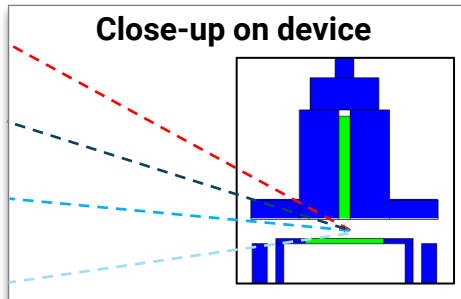# Ready to deploy! MIFTI (UC San Diego) & ZEI (Zap lab)

MIFTI at UC San Diego

- MCNP sims of device/room used to determine the best diagnostic placement .

- Shipping in March; deuterium ops coming soon.
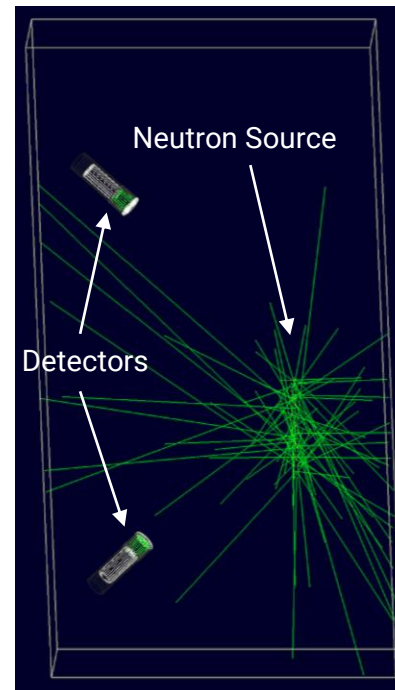
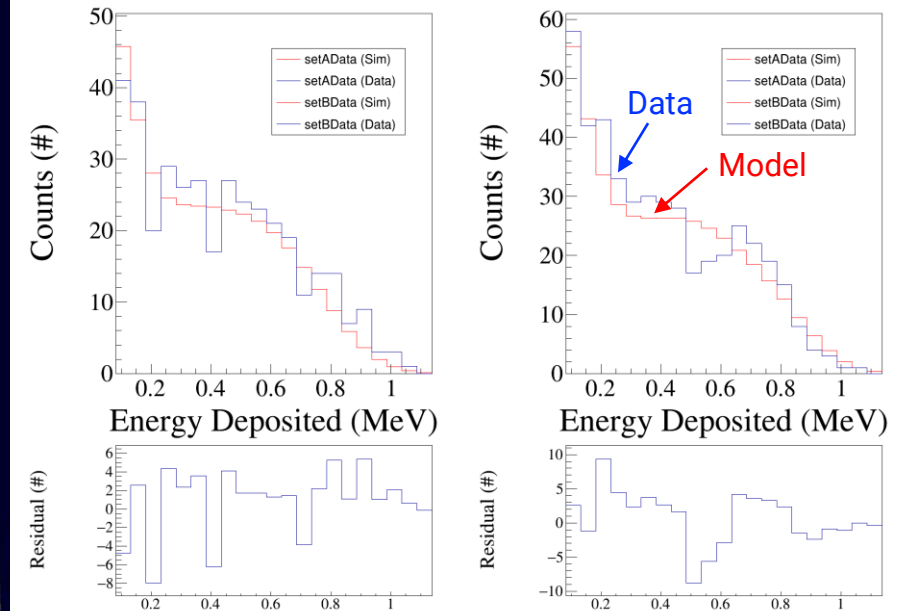**H-factor = expected neutrons / neutrons in vacuum**

Close-up on device

Zap Energy Inc. at Zap Lab

- Monte-Carlo: ions -> neutrons -> protons -> pulses

- Used data pipeline w/ previous FuZE data from ALPHA.

- Plan to take data at first plasma, ~May 2021.

Geant4 Model

Neutron Source

Detectors

Data vs Model

Data

Model

Future Plans

- We aim to work closely with teams at MIFTI and ZEI to fully realize the data analysis methods and uncertainties. This will result in publications to help make the method clear to others.

- We will work with the teams if they want to bring up their own versions of these diagnostics (e.g., procurement, calibration, analysis scripts).

- This work has already been interesting to LLNL's DPF where anisotropy is expected and understanding ion beam dynamics is a core question for device optimization.